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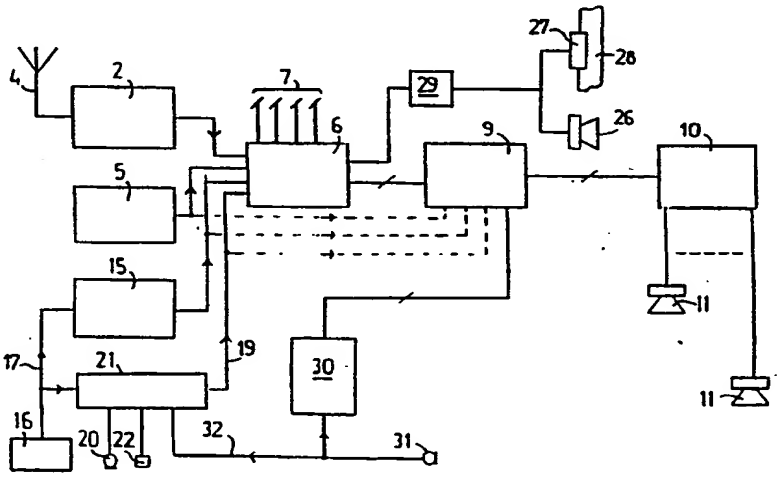
(54) Title: SOUND SYNTHESIZER IN A VEHICLE



(57) Abstract

A noise enhancement system for use in a vehicle comprises a source (15, 20, 22) of signals representing desired sound related to vehicle operation for example the sound of a high power engine being accelerated. In dependence on sensed vehicle operation or experience, the signals are fed, to one or more loudspeakers (11, 26) or vibration actuators (27) so as to create for occupants of the vehicle a desired sound experience. The system can be integrated with one or both of an incar entertainment system and a noise cancellation system.

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Sound synthesizer in a vehicle

DESCRIPTION

The invention relates to the treatment of noise in vehicles, in particular road vehicles.

The driver and passengers in the cabins of conventional passenger cars are exposed to a great deal of externally generated noise, due primarily to the vehicle engine. Various proposals have been made for reduction of such ambient noise but the present invention is concerned with the enhancement of the vehicle noise experienced by the cabin occupants during normal driving conditions.

According to the invention, there is provided a noise enhancement system for use in a vehicle, the system comprising a source of signals representing desired sound related to vehicle operation, and means selectively operable and/or responsive to vehicle operation or experience to apply the signals to one or more loudspeakers or other transducers or vibration actuators so as to create for occupants of the vehicle a desired sound experience.

The source of the signals representing desired sound can be a prerecorded source and/or one or more transducers responsive to noise or to operation of the vehicle or its engine. The transducer means can thus comprise for example one or more microphones or vibration sensors, preferably associated with signal treatment means. The transducer outputs can thus be simply shaped to provide the desired sound. Instead,

the signals providing the desired sound can be obtained from a microprocessor-controlled synthesizer to which the transducer output is supplied, this output being employed to trigger the synthesizer to provide the desired signals at appropriate times. One or more microphones can be located in the vehicle cabin to provide feedback to the signal treatment means. The microprocessor controlling a synthesizer can store signals representing a desired sound to which the synthesizer can be arranged to adapt the transducer output.

The sounds heard by the user of a system embodying the invention can represent for example the sounds of a racing car or other high-performance road vehicle. The system can then be such that these sounds are heard by the cabin occupants whilst the vehicle is being driven, so as to enhance the occupants driving experience.

In particular, the sounds of a high powered engine undergoing sharp acceleration can be produced in response to acceleration of a vehicle fitted with the system of the invention in ordinary driving conditions. The system can be responsive for example to gear changes and/or throttle movement. The sounds need not be limited to engine noise; for example a warning sound, for example, the siren of a police car can be produced when a predetermined vehicle engine speed is exceeded.

The one or more loudspeakers and/or one or more vibration actuators of the system are typically located in the vehicle cabin but instead or as well one or more loudspeakers or actuators can be positioned in the engine compartment, or on appropriate engine or body parts to effect or to modify vibration thereof, so that the sound from them is heard by the vehicle cabin occupants, and by persons outside the vehicle by the

same route as sound from the vehicle engine.

Although the system of the invention can stand alone, it is conveniently integrated with the in-car-entertainment (I.C.E) systems now typically provided in passenger cars. The vehicle operation related sound can be integrated with entertainment sound but is preferably produced in alternation with it, either selectively or according to vehicle operation; for example the former may be heard during acceleration only, giving way to entertainment sound once cruising speed has been reached. The system of the invention can also be integrated with an active noise reduction system which can reduce ambient noise by generating within the vehicle cabin sound vibrations of phase and amplitude such as to cancel or reduce unwanted noise. Noise reduction can thus be operative to prevent interference with the desired sound related to vehicle operation, as well as with entertainment sound, or it may be operative only as long as entertainment sound is being produced or when an integrated system is otherwise out of use.

The invention is further described below, by way of example, with reference to the accompanying drawing in which:

Figure 1 is a block circuit diagram of a combined audio entertainment and noise control or processing system embodying the invention; and

Figure 2 shows part only of a modified form of the system of Figure 1.

The system illustrated in Figure 1 is an integrated system comprising all the components necessary to provide in the cabin of a passenger motor car one or more of enhanced vehicle operation noise, audio entertainment, and ambient noise reduction, as the operator of the system may desire.

The in-car entertainment (I.C.E.) components of the system comprise an audio signal source constituted by at least one of a radio tuner 2 connected to an aerial 4, and a deck or decks 5 for playing one or more of compact discs, digitally recorded tapes or cassettes. The outputs from the tuner 2 and deck or decks 5 are fed to a pre-amplifier 6 fitted with conventional control arrangements 7 for signal source selection and for output adjustment, such as volume and bass and treble controls, or graphic equalization, and switching instruments to be described. These I.C.E. components will typically provide signals on a plurality N of output channels and balance and fader controls will then be provided. The pre-amplifier outputs are supplied by way of a mixer 9, preferably a balanced mixer, to power amplifier means 10 which powers one or more loudspeakers 11 operative in the vehicle cabin.

For enhanced vehicle sound production, the system includes a prerecorded sound source 15 which can comprise a deck of one or other of the types of deck mentioned with reference to the deck 5, but which need not have the usual facility for selective replacement of the signal storage medium. Operation of the source 15 is dependent on a control signal related to vehicle operation, typically throttle movement or gear changes, derived from a transducer 16 and supplied to the source on line 17, so that the source delivers signals representing the sounds of acceleration of a high powered vehicle, or other such desirable sounds, during acceleration or other operation of the vehicle in which the system is installed.

Instead of or as well as the source 15, the system includes one or more microphones 20 providing outputs representing actual vehicle engine noise or the

operating noise of some other vehicle component, which is fed to the pre-amplifier 6, after treatment in a signal treatment unit 21. The signal treatment unit can comprise a relatively simple shaping circuit 21 where this can provide a satisfactory output to the pre-amplifier 6. Instead of or as well as the microphone or microphones 20, the system includes one or more transducers 22, for example vibration sensors, responsive to engine operation to provide signals to the preamplifier 6 after treatment in the signal treatment unit.

Instead of the shaping circuit 21, as shown in Figure 2, the signal treatment unit can be constituted as a synthesizer 24 controlled by a micro-processor 25. The input from the or each microphone 20 or transducer 22 is then used to trigger the generation of a desired output from the synthesizer. Enhanced engine or vehicle interior noise is again provided, again preferably at times dependent on vehicle operation, as by control from the transducer 16.

The outputs of the source 15 and the signal treatment unit are supplied to the pre-amplifier 6 on line 19 for sound production in the vehicle cabin by way of the amplifier means 10 and the loudspeakers 11. In addition or instead the pre-amplifier output derived from the source 15 or the signal treatment unit can be used to drive one or more loudspeakers 26 located externally of the vehicle cabin, for example, in or near the engine compartment of the vehicle so as to enhance the sound actually produced by the vehicle engine, and/or a vibration actuator 27 operatively related to a vehicle panel 28. The loudspeaker 26 and/or actuator 27 is powered by way of one or more power amplifiers 29.

For noise reduction, the system includes an

adaptive noise cancellation controller 30 which may advantageously be of the kind described in WO 88/02912, the contents of which are incorporated herein by reference. The controller 30 provides, on L channels, output signals derived from a reference signal by adaptive filtering carried out by a programmed microprocessor and memory unit in dependence on error signals from one or more microphones 31. The microphones 31 may be inconspicuously located in the cabin and the reference signal may be derived directly from the vehicle engine, as described in WO 88/02912.

The output of the one or more microphones 31, or of one or more similarly located microphones if no noise reduction facilities are provided, can be fed back to the signal treatment unit 21 or to the microprocessor 25, on line 32, so as to provide adaptive control of the unit, as towards a predetermined enhanced noise signal defined in a memory in the unit or in the microprocessor.

The outputs from the pre-amplifier 6 and the controller 30 are fed to the balanced mixer 9 operative to provide outputs for the power amplifier means 10 combining a desired audio signal from one or other of the sources 2 and 5 together with a noise cancelling signals from the controller 30, on which the amplifier control arrangements 7 have no effect.

The system is provided with an on/off switch controlling the power amplifiers 10 and 19 and the mixer 9, and selector switches for selecting any one or more of the enhanced noise facility, the entertainment facility, and the noise reduction facility.

The loudspeakers 11 will conveniently match in number the number of the output channels of the pre-amplifier 6, but there may be M channels between the balanced mixer 12 and the amplifiers 15, where M is

equal to or greater than the larger of the N entertainment channels or the L noise reduction channels.

One or more of the sources 5 and 15 and the unit 21 may incorporate a pre-amplifier and the output or outputs can then be supplied to the mixer 9 directly as indicated in the figure by broken lines.

It will be evident that the invention can be embodied in a variety of ways other than as herein described.

CLAIMS

1. A sound enhancement sys
vehicle, the system comprising a sou
signals representing desired sound r
operation, and means (6,16) selective
responsive to vehicle operation and/
employ the signals to provide outp
means (11,17) so as to create for an
vehicle a desired sound experience.

2. A system as claimed in cla
source of signals representing the
comprises at least one of a prereco
(15), at least one microphone (20)
vehicle or engine noise, and a vibra
responsive to vehicle or engine-genera

3. A system as claimed in clai
source of signals representing th
comprises one or both of the microph
sensor (22), and wherein a signal trea
arranged to shape the signals therefro
outputs.

4. A system as claimed in clai
source of the signals representing the
comprises one or both of the microph
sensor (22) and wherein a signal
receiving the signals comprises a sy
arranged to provide the outputs.

5. A system as claimed in clai
microprocessor (25) controlling the s
includes a store in which are s
representing a desired sound, and the
arranged to adapt the signals from the
stored signals.

6. A system as claimed in claim
association with a noise cancellatio

including an error sensing microphone (31), the microphone output being supplied to the signal treatment unit (21;24,25) for adaptive control thereof.

7. A system as claimed in any preceding claim wherein the signals are employed to provide the outputs in response to signals from a transducer (16) responsive to vehicle operation.

8. A system as claimed in any preceding claim wherein the transducer means comprises one or more loudspeakers (27) located in the region of the vehicle engine.

9. A system as claimed in any preceding claim wherein the transducer means comprises one or more loudspeakers (11) located in the vehicle cabin.

10. A system as claimed in claim 8 wherein the loudspeakers (11) form part of at least one of an in-car entertainment system and a noise cancellation system.

11. A system as claimed in any preceding claim wherein the transducer means comprises at least one actuator for causing vibration of a vehicle panel.

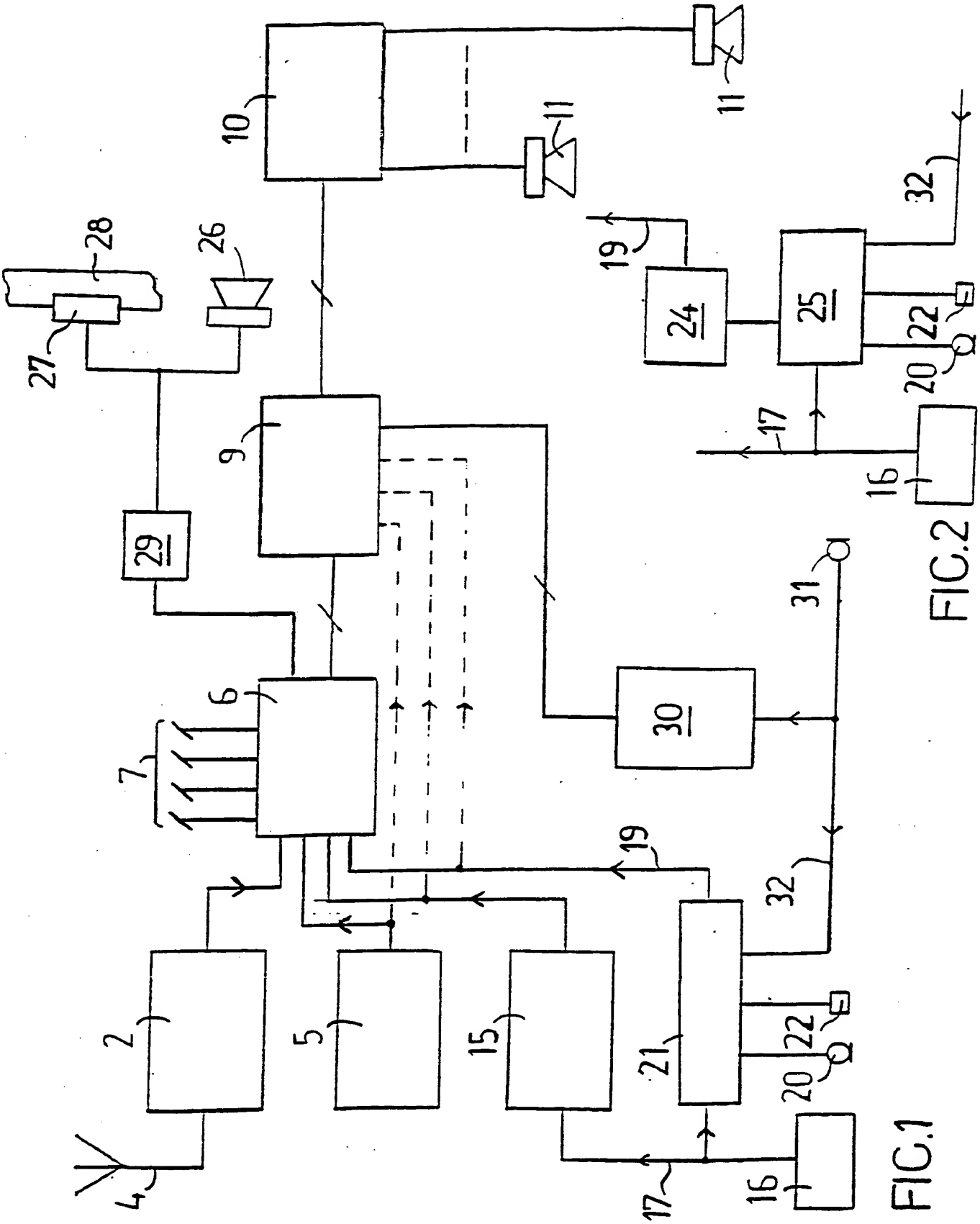

FIG.2

FIG.1

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/00597

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: G 10 K 15/02

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	G 10 K, A 63 H, G 09 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US, A, 4274225 (KNAUFF et al.) 23 June 1981 see column 3, lines 37-48; figure 1 --	1
A	US, A, 4289307 (MARSHALL et al.) 15 September 1981 see column 2, line 58 - column 3, line 9; column 4, lines 19-32; figure 1 --	2
A	US, A, 4219962 (DANKMAN et al.) 2 September 1980 see column 2, lines 35-38; column 6, lines 37-44; column 7, lines 21-53; column 9, lines 31-36 --	1
A	DE, A, 2734948 (INDUSTRIEANLAGEN -BETRIEBS-GESELLSCHAFT) 15 February 1979	5

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* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
16th July 1990	16 AOUT 1990
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	MISS T. TAZELAAR

Form PCT/ISA/210 (second sheet) (January 1985)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, 11 with indication, where appropriate, of the relevant passages	Relevant to Claim No.
	see page 2, lines 2-11	
	--	
A	WO, A, 88/02912 (ADAPTIVE CONTROL LTD) 21 April 1988 see abstract; figure 5 (cited in the application)	6
	--	
A	GB, A, 2018144 (MABUCHI MOTOR K.K.) 17 October 1979 see page 1, lines 37-56	11

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9000597 SA 36218

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 09/08/90
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4274225	23-06-81	None	
US-A- 4289307	15-09-81	CA-A- 1123024	04-05-82
US-A- 4219962	02-09-80	None	
DE-A- 2734948	15-02-79	None	
WO-A- 8802912	21-04-88	GB-A- 2203016	05-10-88
		EP-A- 0285632	12-10-88
		GB-A- 2201858	07-09-88
		JP-T- 1501344	11-05-89
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		DE-A,C 2909523	20-09-79
		US-A- 4258499	31-03-81

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